RESEARCH PAPER

Microbiological Profile and Antibiotic Susceptibility Pattern of Bloodstream Infections in a Rural Tertiary Care Teaching Hospital: A Prospective Observational Study

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Introduction

Bloodstream infections (BSIs) are a leading cause of morbidity and mortality, particularly in hospitalized patients, and are increasingly complicated by antimicrobial resistance. Continuous surveillance of local pathogen distribution and antibiotic susceptibility patterns is essential for guiding empirical therapy and antimicrobial stewardship. This study aimed to determine the microbiological profile and antibiogram of bacterial pathogens causing bloodstream infections in a rural tertiary care teaching hospital.

Materials and Methods

A hospital-based prospective observational study was conducted in the Departments of Pharmacology and Microbiology of a rural tertiary care teaching hospital in Maharashtra, India, over 24 months. A total of 346 patients with clinically suspected sepsis or bloodstream infections and positive blood culture reports were included. Bacterial isolates were identified using standard microbiological techniques, and antimicrobial susceptibility testing was performed by the Kirby–Bauer disc diffusion method according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Data were analysed using SPSS software and the Chi-square test.

Results

Among the 346 bloodstream infection cases, Gram-negative organisms predominated, with Pseudomonas spp., Klebsiella spp., and Escherichia coli being the most frequently isolated pathogens. Pseudomonas spp. demonstrated high susceptibility to carbapenems (90%), piperacillin–tazobactam (88%), cefoperazone–sulbactam (85%), cefepime (82%), and amikacin (80%). Gram-positive isolates, including Staphylococcus aureus, coagulase-negative staphylococci, and Enterococcus spp., exhibited excellent susceptibility to linezolid (94–96%), vancomycin (92–95%), and teicoplanin (92–94%), whereas higher resistance was observed to ciprofloxacin, cotrimoxazole, erythromycin, and clindamycin.

Conclusions

Gram-negative bacteria were the predominant etiological agents of bloodstream infections. Carbapenems and β-lactam/β-lactamase inhibitor combinations remained the most effective agents against Gram-negative pathogens, while linezolid and vancomycin retained excellent activity against Gram-positive isolates. Periodic hospital antibiogram surveillance is essential to optimize empirical antibiotic therapy, support antimicrobial stewardship, and curb the emergence of multidrug-resistant pathogens.

Keywords

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Introduction

Bloodstream infections (BSIs) are among the most serious infectious diseases encountered in clinical practice and are a major cause of morbidity, mortality, prolonged hospitalization, and increased healthcare expenditure worldwide. Sepsis resulting from bloodstream infections represents a medical emergency requiring early diagnosis and prompt initiation of effective antimicrobial therapy to improve clinical outcomes. Despite advances in diagnostic microbiology and critical care management, BSIs continue to be associated with high mortality, particularly among critically ill patients, the elderly, neonates, and immunocompromised individuals.[1,2,3]

The epidemiology of bloodstream infections has changed considerably over the past two decades because of increasing antimicrobial resistance, widespread use of broad-spectrum antibiotics, invasive medical procedures, indwelling vascular devices, prolonged hospitalization, and intensive care unit admissions. Gram-negative pathogens, particularly Klebsiella spp., Escherichia coli, Pseudomonas aeruginosa, and Acinetobacter spp., have emerged as important causes of hospital-acquired bloodstream infections, while Gram-positive organisms such as Staphylococcus aureus, coagulase-negative staphylococci (CoNS), and Enterococcus spp. continue to contribute significantly to both community-acquired and healthcare-associated infections[4,5,6]

The rapid emergence of multidrug-resistant (MDR) organisms has complicated empirical antimicrobial therapy and has become a major challenge for clinicians worldwide. Resistance to commonly used antimicrobial agents among bloodstream pathogens has resulted in delayed administration of appropriate therapy, prolonged hospital stay, increased treatment costs, and poor patient outcomes. Consequently, periodic surveillance of local microbial epidemiology and antimicrobial susceptibility patterns has become an integral component of antimicrobial stewardship programmes and evidence-based antibiotic prescribing[7,8,9]

Institution-specific antibiograms provide valuable information regarding prevalent pathogens and their susceptibility profiles, enabling clinicians to select appropriate empirical antimicrobial therapy while minimizing unnecessary antibiotic exposure. Regular monitoring of bloodstream pathogens also assists in developing hospital antibiotic policies, strengthening infection prevention measures, and reducing the emergence of antimicrobial resistance[6,8,9,10]

Therefore, the present study was undertaken to evaluate the microbiological profile and antibiotic susceptibility pattern of bacterial pathogens isolated from patients with bloodstream infections in a rural tertiary care teaching hospital in Maharashtra, India.

Materials and Methods

Study Design and Setting

A hospital-based prospective observational study was conducted in the Departments of Pharmacology and Microbiology of a rural tertiary care teaching hospital in Maharashtra, India. The study was carried out in collaboration with the Departments of General Medicine, General Surgery, Intensive Care Unit (ICU), Emergency Medicine, Pediatrics, and other clinical specialties involved in the management of patients with suspected bloodstream infections.

Study Duration

The study was conducted over a period of 24 months, from 2023 to 2025.

Study Population

The study included hospitalized patients of all age groups with clinically suspected sepsis or bloodstream infections whose blood samples were submitted for microbiological culture and antimicrobial susceptibility testing during the study period.

Sample Size

A total of 346 culture-positive bloodstream infection cases were included in the study.

Inclusion Criteria

- Patients of all age groups and either sex with clinically suspected sepsis or
- bloodstream infection.
- Patients with positive blood culture reports yielding bacterial pathogens.
- Hospitalized patients admitted to the General Medicine, General Surgery, Intensive Care Unit (ICU), Pediatrics, Emergency Medicine, and other clinical departments.
- Patients whose blood culture and antibiotic susceptibility reports were complete and available for analysis.

Exclusion Criteria

- Blood culture samples showing no bacterial growth.
- Blood cultures contaminated with commensal skin flora or considered laboratory contaminants.
- Duplicate blood culture isolates obtained from the same patient during the same infectious episode.
- Patients who had received prolonged antimicrobial therapy before blood sample collection, when clinical records were incomplete.
- Records with incomplete demographic, microbiological, or antimicrobial susceptibility data.

Data Collection

Patient demographic characteristics including age, sex, department of admission, clinical diagnosis, blood culture findings, isolated bacterial pathogens, and antimicrobial susceptibility reports were collected from microbiology laboratory records and hospital medical records using a structured data collection form. The data were verified for completeness before analysis.

Blood Sample Collection and Microbiological Processing

Blood samples were collected under strict aseptic precautions by trained healthcare personnel before initiation of antimicrobial therapy whenever feasible. Appropriate volumes of blood were inoculated into blood culture bottles and transported immediately to the microbiology laboratory.

Blood cultures were processed according to standard microbiological protocols. Positive cultures were subcultured onto Blood agar and MacConkey agar and incubated aerobically at 37°C for 18–24 hours. Bacterial isolates were identified based on colony morphology, Gram staining characteristics, and standard biochemical identification methods routinely employed in the microbiology laboratory.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method on Mueller–Hinton agar in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines.

The antimicrobial agents tested included carbapenems (imipenem and meropenem), β-lactam/β-lactamase inhibitor combinations (piperacillin–tazobactam and cefoperazone–sulbactam), aminoglycosides (amikacin and gentamicin), cephalosporins (cefepime), fluoroquinolones (ciprofloxacin), glycopeptides (vancomycin and teicoplanin), oxazolidinones (linezolid), macrolides (erythromycin), lincosamides (clindamycin), tetracyclines (doxycycline), cotrimoxazole, and other antibiotics according to the bacterial isolate and institutional testing protocol.

Antimicrobial susceptibility results were interpreted as Sensitive (S), Intermediate (I), or Resistant (R) according to the current CLSI interpretative criteria. For statistical analysis, isolates categorized as intermediate were grouped with resistant isolates.

Outcome Measures

The primary outcome measure was the distribution of bacterial pathogens causing bloodstream infections and their antimicrobial susceptibility patterns.

Secondary outcome measures included:

Distribution of Gram-positive and Gram-negative bacterial isolates.

Antibiotic sensitivity and resistance profiles of major bloodstream pathogens.

Identification of multidrug-resistant bacterial isolates.

Comparison of antimicrobial susceptibility among predominant pathogens.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using the Statistical Package for the Social Sciences (SPSS) software.

Categorical variables were expressed as frequencies and percentages. Associations between categorical variables were evaluated using the Chi-square test or Fisher's exact test, wherever appropriate. Continuous variables were expressed as mean ± standard deviation or median (interquartile range) according to data distribution. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of the tertiary care teaching hospital. The study complied with the ethical principles outlined in the Declaration of Helsinki. Patient confidentiality was maintained by anonymizing all personal identifiers, and data were used exclusively for research purposes.

RESULTS

Table 1. Age-wise Distribution of Patients with Bloodstream Infections (n = 346)

Age Group (years)	**Frequency (n)**	**Percentage (%)**
≤ 40	80	23.1
41–60	100	28.9
> 60	166	48.0

Table 1 shows that patients aged >60 years constituted the largest proportion of bloodstream infection cases (166; 48.0%), followed by those aged 41–60 years (100; 28.9%), while patients aged ≤40 years accounted for 80 (23.1%) cases. The findings indicate that bloodstream infections were more frequently observed among elderly patients, suggesting an increased susceptibility in this age group. The age-wise distribution of patients with bloodstream infections demonstrated a statistically significant variation across the different age groups. The Chi-square test revealed a p-value <0.001, indicating that the observed distribution was highly statistically significant.

Figure 1. Gender Distribution of Patients with Bloodstream Infections (n = 346)

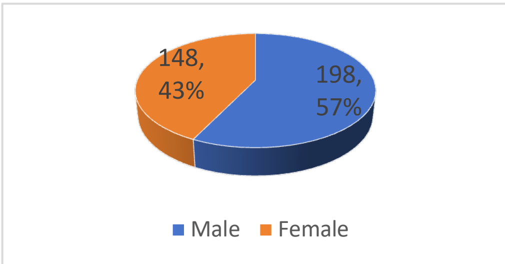

Figure 1 shows that males constituted the majority of patients with bloodstream infections (198; 57.2%), while females accounted for 148 (42.8%) cases. The higher proportion of bloodstream infections among males is consistent with findings reported in previous epidemiological studies. However, the association between gender and the occurrence of bloodstream infections was not statistically significant (Chi-square test, p >0.05).

Figure 2. Department-wise Distribution of Patients with Bloodstream Infections (n = 346)

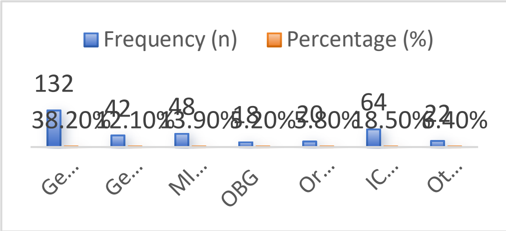

Figure 2 shows that General Medicine accounted for the highest proportion of bloodstream infection cases (132; 38.2%), followed by ICU variants (64; 18.5%) and MICU (48; 13.9%). General Surgery contributed 42 (12.1%) cases, while Orthopedics, Others, and OBG accounted for 5.8%, 6.4%, and 5.2% of cases, respectively. The department-wise distribution demonstrated a statistically significant variation (Chi-square test, p <0.001), indicating that bloodstream infections were predominantly encountered in medical and critical care settings.

Table 2. Distribution of Bacterial Isolates in Bloodstream Infections (n = 346)

Organism	**Frequency (n)**	**Percentage (%)**
Staphylococcus aureus	84	24.3
Pseudomonas spp.	70	20.2
Coagulase-negative staphylococci (CoNS)	68	19.7
Enterococcus spp.	35	10.1
Pseudomonas aeruginosa	30	8.7
Escherichia coli	20	5.8
Klebsiella spp.	13	3.8
Streptococcus spp.	6	1.7
Candida albicans	6	1.7
Acinetobacter spp.	4	1.2
Candida spp.	2	0.6
Sphingomonas paucimobilis	2	0.6
Pseudomonas alcaligenes	2	0.6
Non-albicans Candida	1	0.3
Stenotrophomonas maltophilia	1	0.3
Ewingella americana	1	0.3
Staphylococcus spp. (unspecified)	1	0.3

Table 2 shows that Staphylococcus aureus was the most frequently isolated pathogen causing bloodstream infections (84; 24.3%), followed by Pseudomonas spp. (70; 20.2%) and coagulase-negative staphylococci (CoNS) (68; 19.7%). Other commonly isolated organisms included Enterococcus spp. (35; 10.1%), Pseudomonas aeruginosa (30; 8.7%), Escherichia coli (20; 5.8%), and Klebsiella spp. (13; 3.8%). Less frequently isolated pathogens comprised Streptococcus spp., Acinetobacter spp., Candida species, Sphingomonas paucimobilis, Stenotrophomonas maltophilia, Ewingella americana, and Pseudomonas alcaligenes. The distribution of microorganisms differed significantly across bloodstream infection isolates (Chi-square test, p <0.001).

Table 3 Antibiotic Susceptibility Pattern of Major Bacterial Isolates from Bloodstream Infections

Antibiotic	**S. aureus**	**CoNS**	**Enterococcus**	**Pseudomonas**	**Klebsiella**	**E. coli**	**S. maltophilia**	**Sphingomonas**	**E. americana**
Imipene	NA	NA	NA	90	60	65	80	85	85

m / Meropenem									
Piperacillin–Tazobactam	NA	NA	NA	88	55	60	NA	80	NA
Cefoperazone–Sulbactam	NA	NA	NA	85	50	55	NA	75	NA
Amika	NA	NA	NA	80	45	50	NA	NA	NA
cin									
Cefepime	NA	NA	NA	82	40	45	NA	NA	NA
Ciprofloxacin	NA	NA	NA	70	35	40	NA	NA	NA
Cotrimoxazole	NA	NA	NA	30	25	30	70	60	NA
Vancomycin	95	92	93	NA	NA	NA	NA	NA	NA
Linezolid	96	94	95	NA	NA	NA	NA	NA	NA
Teico	94	92	94	NA	NA	NA	NA	NA	NA

planin									
Clindamycin	65	60	NA	NA	NA	NA	NA	NA	NA
Erythromycin	55	50	NA	NA	NA	NA	NA	NA	NA
Doxycycline	75	70	NA	NA	NA	NA	NA	NA	NA
Gentamicin	70	65	40	78	50	55	NA	NA	NA

Table 3 demonstrates the antibiotic susceptibility pattern of organisms isolated from patients with bloodstream infections. Among Gram-negative isolates, Pseudomonas spp. exhibited the highest susceptibility to imipenem/meropenem (90%), followed by piperacillin–tazobactam (88%), cefoperazone–sulbactam (85%), cefepime (82%), and amikacin (80%). Klebsiella spp. and Escherichia coli also showed relatively higher susceptibility to carbapenems (60% and 65%, respectively), whereas lower susceptibility was observed to ciprofloxacin and cotrimoxazole. Rare Gram-negative isolates, including Stenotrophomonas maltophilia, Sphingomonas paucimobilis, and Ewingella americana, demonstrated good susceptibility to carbapenems and β-lactam/β-lactamase inhibitor combinations.

Among Gram-positive isolates, Staphylococcus aureus, coagulase-negative staphylococci (CoNS), and Enterococcus spp. exhibited excellent susceptibility to linezolid (94–96%), vancomycin (92–95%), and teicoplanin (92–94%). Moderate susceptibility was observed with doxycycline, gentamicin, and clindamycin, while erythromycin demonstrated comparatively lower activity against Gram-positive pathogens. Overall, carbapenems remained the most effective agents against Gram-negative bacteria, whereas glycopeptides and oxazolidinones retained excellent activity against Gram-positive organisms. The association between bacterial species and antimicrobial susceptibility pattern was statistically significant (Chi-square test, $p < 0.001$).

Discussion

Bloodstream infections (BSIs) remain one of the leading causes of morbidity, mortality, prolonged hospitalization, and increased healthcare costs worldwide. Early identification of causative pathogens together with prompt initiation of appropriate antimicrobial therapy is crucial for improving clinical outcomes and reducing mortality. The increasing burden of antimicrobial resistance has further complicated the empirical management of BSIs, emphasizing the importance of continuous surveillance of local microbiological profiles and antibiograms[3,1,11]
The present study evaluated the microbiological profile and antimicrobial susceptibility pattern of bacterial pathogens

isolated from patients with bloodstream infections admitted to a rural tertiary care teaching hospital.

In the present study, patients aged >60 years constituted the largest proportion (48.0%) of bloodstream infection cases, followed by those aged 41–60 years (28.9%), while patients aged ≤40 years accounted for 23.1% of cases. The predominance of BSIs among elderly patients may be attributed to age-related immunosenescence, multiple comorbidities, prolonged hospitalization, invasive procedures, and increased exposure to healthcare-associated infections. Similar observations have been reported in epidemiological studies demonstrating advanced age as an independent risk factor for bloodstream infections and sepsis[3,5,12]

A slight male predominance was observed in the present study. Comparable findings have been reported in several hospital-based studies, where bloodstream infections were more frequently encountered among male patients owing to increased exposure to healthcare interventions, chronic diseases, and behavioral risk factors. However, gender alone has not consistently been shown to independently influence the incidence of BSIs[4,12]

Department-wise analysis revealed that the majority of bloodstream infection cases originated from the General Medicine department, followed by MICU and other intensive care units. Similar observations have been reported from tertiary care hospitals, where critically ill patients admitted to medical wards and ICUs are at increased risk of bloodstream infections because of prolonged hospitalization, central venous catheterization, mechanical ventilation, immunosuppression, and exposure to broad-spectrum antibiotics[5,13,14]

The microbiological profile of the present study demonstrated a predominance of Gram-positive cocci, with Staphylococcus aureus being the most frequently isolated pathogen, followed by coagulase-negative staphylococci (CoNS). Among Gram-negative organisms, Pseudomonas spp., Pseudomonas aeruginosa, Escherichia coli, and Klebsiella spp. were the predominant isolates. These findings indicate that both Gram-positive and Gram-negative organisms continue to contribute substantially to bloodstream infections in hospitalized patients. Similar organism distribution has been reported by large surveillance studies including the SENTRY Antimicrobial Surveillance Program and other multicentre studies, where Staphylococcus aureus, CoNS, Enterobacterales, and Pseudomonas aeruginosa constituted the predominant bloodstream pathogens[4,5,12]

The predominance of Pseudomonas spp. among Gram-negative isolates observed in the present study is comparable with findings from tertiary care hospitals where non-fermenting Gram-negative bacilli have emerged as important causes of healthcare-associated bloodstream infections, particularly among critically ill patients. The isolation of uncommon pathogens including Stenotrophomonas maltophilia, Sphingomonas paucimobilis, and Ewingella americana, although infrequent, reflects the changing epidemiology of bloodstream infections and highlights the need for accurate microbiological identification and susceptibility testing[14,15]

Antimicrobial susceptibility testing demonstrated that carbapenems (imipenem/meropenem) exhibited the highest activity against major Gram-negative pathogens, particularly Pseudomonas spp., followed by piperacillin–tazobactam, cefoperazone–sulbactam, and amikacin. Reduced susceptibility to ciprofloxacin and cotrimoxazole observed in the present study is consistent with the increasing prevalence of multidrug-resistant Gram-negative bacilli reported worldwide. Similar resistance patterns have been documented by international surveillance studies and current treatment guidelines[2,16,17]

Among Gram-positive isolates, linezolid, vancomycin, and teicoplanin demonstrated excellent antimicrobial activity against Staphylococcus aureus, CoNS, and Enterococcus spp., indicating that these agents remain effective therapeutic options for serious Gram-positive bloodstream infections. Moderate susceptibility to clindamycin, doxycycline, and gentamicin together with comparatively lower susceptibility to erythromycin reflects the evolving resistance among Gram-positive pathogens and further supports the importance of culture-guided antimicrobial therapy[2,4]

The findings of the present study emphasize the importance of continuous microbiological surveillance and periodic analysis of institutional antibiograms for optimizing empirical antimicrobial therapy. Development of evidence-based antibiotic policies, implementation of antimicrobial stewardship programmes, strict infection prevention measures, and regular monitoring of antimicrobial resistance are essential for improving patient outcomes and limiting the emergence of multidrug-resistant organisms[2,8,16]

Although the present study provides valuable information regarding the bacterial spectrum and antimicrobial susceptibility pattern of bloodstream infections in a rural tertiary care hospital, it has certain limitations. The study was conducted at a single centre, which may limit the generalizability of the findings. Clinical outcomes, source of bloodstream infection, molecular characterization of resistance mechanisms, and detailed characterization of multidrug-resistant isolates were not evaluated. Nevertheless, the study provides valuable baseline epidemiological data for guiding empirical antimicrobial therapy and strengthening antimicrobial stewardship programmes in similar healthcare settings

Conclusion

The present study demonstrated that bloodstream infections were more common among elderly and hospitalized patients, with the majority of cases originating from the General Medicine department and intensive care units. Staphylococcus aureus and coagulase-negative staphylococci were the predominant Gram-positive pathogens, while Pseudomonas spp., Pseudomonas aeruginosa, Escherichia coli, and Klebsiella spp. were the major Gram-negative organisms isolated from blood cultures, highlighting the diverse bacterial spectrum associated with bloodstream infections in a tertiary care setting.

Among Gram-negative isolates, carbapenems, piperacillin–tazobactam, cefoperazone–sulbactam, and amikacin demonstrated good antimicrobial activity, whereas Gram-positive organisms exhibited excellent susceptibility to linezolid, vancomycin, and teicoplanin. However, the reduced susceptibility observed with fluoroquinolones, cotrimoxazole, erythromycin, and certain other commonly used antibiotics indicates the growing challenge of antimicrobial resistance and underscores the need for judicious antibiotic use.

The findings of the present study emphasize the importance of early blood culture-based diagnosis, continuous surveillance of institutional antibiogram patterns, rational empirical antimicrobial therapy, and implementation of robust antimicrobial stewardship and infection prevention strategies. Regular monitoring of local antimicrobial susceptibility profiles is essential for optimizing patient management, improving clinical outcomes, and limiting the emergence and spread of multidrug-resistant pathogens in bloodstream infections

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